Exhibit E

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

SECURITIES AND EXCHANGE COMMISSION, Plaintiff, v. RIPPLE LABS INC., BRADLEY GARLINGHOUSE, and CHRISTIAN A. LARSEN, Defendants.	20-cv-10832 (AT)

Expert Report of Prof. Carol Osler

I. Background and Qualifications

1. I am the Martin and Ahuva Gross Professor of Financial Markets and Institutions at Brandeis University. My Curriculum Vitae is included as Exhibit A to this report.

2. I have earned an MA and Ph.D. in Economics, with specialization in International Finance, from Princeton University. That was preceded by a BA in Economics from Swarthmore College. At Brandeis I usually teach about 125 master's students and supervise one or two Ph.D. theses each year. Prior to teaching at Brandeis, I taught at Dartmouth's Amos Tuck School of Business, Northwestern University's Kellogg School of Management, Columbia University's Economics Department and, separately, its School for International and Public Affairs. I have also taught a Ph.D. course at the Norwegian Business School (BI).

3. At Tuck and Kellogg I taught an MBA course entitled "International Capital Markets," in which foreign exchange ("FX") markets naturally occupied some weeks. At Brandeis I teach a master's-level course on financial markets. At its inception the course was called "Foreign Exchange," and it was entirely dedicated to exchange rates and currency trading. Over the years I added substantial material on equity, bond, and commodity markets, so the course title was changed to "Trading and Exchanges."

4. My research primarily focuses on currency markets and exchange rates, about which I have published roughly twenty papers. All but two of these appeared in A-rated journals, according to the well-regarded Australian Business Deans Council ("ABDC") ranking. Five of my research articles were published by the ABDC's highest quality (A*) journals including the *Journal of Finance*, the *Journal of Financial and Quantitative Analysis*, and the *Review of Finance*.

5. I have been retained by Kellogg, Hansen, Todd, Figel & Frederick, PLLC, counsel to Defendant Ripple Labs Inc. ("Ripple"), to offer my expert opinions in this case. I am being compensated at the rate of $600 per hour for my work on this matter. My compensation is not dependent upon the outcome of this case, and all of the opinions I express in this report are my own. The materials I have relied on and considered in forming my opinions are cited throughout this report.

II. Expert Assignment and Opinions

6. I have been asked to offer an expert opinion on the following questions

Q1. From an economic perspective, does the digital asset XRP function as a "currency"?

Q2. Does Ripple's On-Demand Liquidity product ("ODL") present an economically sound option for making cross-border and cross currency payments? Why or why not?

7. For reasons described in greater detail below, my opinions on these questions are as follows:

Q1. XRP fits the economic definition of a "currency" because it has the functions and attributes commonly assigned to currencies by experts.

- Functions: XRP serves as a medium of exchange, means of payment, unit of account, and store of value.
- Attributes: XRP is durable, portable, divisible, uniform, acceptable, in limited supply, and inexpensive to store.

Q2. ODL, which operates using the open-source XRP Ledger system and leverages the digital asset XRP as a bridge currency, presents an economically sound option for making cross-border and cross-currency payments.

- Compared to the dominant traditional payments platforms, ODL provides less costly, faster, and more transparent payments.
- Compared to the dominant cryptocurrency ledger systems, the XRP Ledger is faster, less costly, equally transparent, more scalable, and less resource-intensive.
- The XRP Ledger, which ODL leverages, not only realizes the advantages of digital technologies but advances them by implementing original solutions to well-known challenges in computer science.
- XRP is a logical part of its eponymous Ledger system. It embodies a centuries-old solution for limiting the unmanageably extreme multiplicity of connections among currencies.
- The dominant payment platforms have not fully incorporated the potential advantages of digital technologies. Furthermore, the modernization process is proceeding slowly in part because the dominant payment processors have both the incentives and the power to maintain high costs.
- Ripple faces specific, well-known challenges as a start-up. The dominant firms in its industry benefit from "network externalities" that create barriers to entry.
- Ripple follows a strategy known as "disruptive innovation" in promoting its ODL system. According to economists, this strategy is appropriate for a firm, like Ripple, which has technological advantages but financial disadvantages relative to the dominant firms.

III. Opinion on Question 1: XRP has the functions and attributes commonly assigned to currencies by experts

8. To ascertain whether XRP has the economic characteristics of a currency, one must first identify the nature of a currency.[1] It is commonly assumed that all currencies are state-sponsored, in part because the currencies in use for exchanging goods and services have been state-sponsored for roughly two centuries. However, state sponsorship is neither necessary nor sufficient for legitimate currencies. Currencies came into use as early 40,000 years ago,[2] far before the emergence of states.[3] Early currencies included natural objects that are independent of any government by definition, such as feathers, ivory, jade, cows, and shells. Early currencies also included objects that were made by humans without government guidance or control, such as beads, drums, gongs, knives, spades, vodka, wampum, and zappozats (decorated axes).[4] As recently as WWII a man-made currency with no government endorsement – cigarettes – circulated as currency in a prisoner-of-war camp.[5]

9. Economists and economic anthropologists have identified four standard functions of a currency and a number of attributes that promote a currency's success. This section reviews these functions and attributes and concludes that XRP demonstrates them all.

10. Evidence gathered by economic anthropologists indicates that the first function for currencies was means of payment in circumstances dictated by social norms. Two common examples provided are (i) bride payments and other gift exchanges and (ii) debt repayments, such as compensation to a crime victim.[6]

11. Economists typically highlight that currencies have long served the function of medium of exchange, meaning they enabled efficient exchanges of goods and services. Under a barter

[1] Note: The terms currency and money are used interchangeably in this document. This is consistent with today's common practice as manifested in phrases such as a "currency crisis" and "currency markets" (synonymous with FX markets).

[2] Kusimba, Chapurukha (19 June 2017). When – and why – did people first start using money? *The Conversation*. https://theconversation.com/when-and-why-did-people-first-start-using-money-78887.

[3] Spencer, Charles S. (2010). Territorial expansion and primary state formation. *Proceedings of the National Academy of Sciences of the United States of America* (PNAS) 107(16): 7119, 7126. https://doi.org/10.1073/pnas.1002470107

[4] Davids, Glyn (2002). *A history of money from ancient times to the present day, 3rd ed.* (Cardiff: University of Wales Press).

[5] Radford, R.A. (1945). The economic organisation of a POW camp. *Economica* 12(48): 189-201.

[6] Kusimba (2008), *op. cit.*

system, which is considered the main alternative, any exchange requires a hard-to-find "double-coincidence of wants." To illustrate: the farmer with excess eggs who needs an ox must find someone willing to part with an ox in exchange for eggs. With currencies the farmer can acquire the ox in two steps: first, sell eggs for money; second, purchase the ox with money. The eggs can be sold to anyone who is willing to pay money; the ox can be purchased from anyone willing to sell an ox for money. Because currencies eliminate the need for a double-coincidence of wants, the number of feasible routes to converting eggs into an ox is vastly multiplied.

12. Economists also highlight two additional functions of a currency: unit of account and store of value.[7] A unit of account is a measure of value. To disentangle this concept from a medium of exchange, it helps to recognize the following: British pounds and shillings had no physical form until they were first minted around 1500.[8] Instead, pounds and shillings existed as concepts, and were used to measure castle inventories and the like, as early as the eighth century C.E. During the eight centuries from the 700s to the 1500s, the main medium of exchange in Britain was the silver penny (worth 1/12 shilling), and other coins of relatively small value such as the groat (worth four pence), first issued in 1361. A store of value is an asset that will still be valuable in the future.

13. XRP serves all four of the functions of a currency just discussed. Means of payment: Every transaction on the XRP Ledger, including transactions through Ripple's ODL product, described in Section IV, costs a fraction of an XRP. That is, XRP is used to pay for the service of liquidity. In addition to that payment for use of the XRP Ledger itself, XRP can be used to pay for physical goods through online platforms including Bitcoin Superstore and Shopify and travel through Travala.[9] Medium of exchange: One function of XRP is to serve as a medium of exchange between two other currencies and currently serves that function for the client firms using Ripple's ODL. Unit of account: XRP is used to value other things available to exchange.

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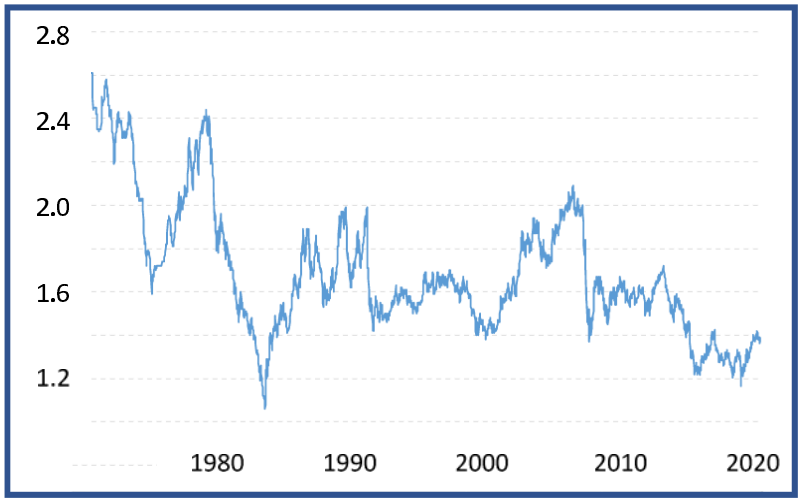
[7] Federal Reserve Bank of St. Louis. Functions of money. *The Economic Lowdown Podcast Series.* https://www.stlouisfed.org/education/economic-lowdown-podcast-series/episode-9-functions-of-money. Virtually any standard economics textbook will list the same three functions of money. *See, e.g.*, Mankiw, N. Gregory (2008). *Principles of Economics* 5th ed., (Southwestern Cengage Learning, Ohio): p. 642.

[8] Lowther, Ed (14 February 2014). A short history of the pound. *BBC News*. https://www.bbc.com/news/uk-politics-26169070.

[9] https://www.xrparcade.com/xrpecosystem/.

14. The final function commonly ascribed to currencies, store of value, benefits from a more extended discussion. Specifically, volatility does not necessarily negate the ability to serve as a store of value. This is illustrated in Figure 1 by the exchange rate between the U.K. pound and the US dollar, which has ranged from $1.1/£ and $2.5/£ since the early 1970s. Prior to the early 1970s this exchange rate was generally fixed, as were virtually all exchange rates worldwide. Importantly, the shift from fixed to fluctuating exchange rates had no bearing on whether the US dollar and the UK pound were still considered currencies. By this same logic, the existence of day-to-day fluctuations in XRP exchange rates does not change the nature of XRP as a currency.

Figure 1: Exchange rate between U.K. pound and U.S. dollar (as dollars per pound)[10]



15. A wide range of prices between a currency, on the one hand, and goods and services, on the other, is also irrelevant to the nature of that currency. At the time of writing there is substantial uncertainty about US inflation, or equivalently there is concern about the US dollar's future value in terms of goods and services. No one questions, however, whether the US dollar is a currency. Likewise, the rate at which Venezuelan bolivar loses value in terms of goods and services has been extremely difficult to predict in recent years. In 2018, for example, that currency lost 88% of its value in February, 1% in September, and 85% in December. This has no influence on whether the bolivar is a currency.

16. The Federal Reserve, the world's dominant central bank for the past century, identifies six attributes that enhance the use value of a currency: durability, portability, divisibility, uniformity,

[10] Source: https://www.macrotrends.net/2549/pound-dollar-exchange-rate-historical-chart.

acceptability, and limited supply.[11] Other economists often include low storage costs on this list.[12] An ideal currency would have all these attributes, but no single attribute is individually necessary and many objects have succeeded as currencies with only a few. Cows were a very early form of money in societies from Egypt[13] to Ireland[14] and remain "the preferred form of currency" in South Sudan even today.[15] However, cows are not portable, divisible, or uniform, their durability is limited, and they are costly to store. For many centuries boulders have served as currency on the Micronesian island of Yap, though they are extraordinarily difficult to transport and divide.[16]

17. Cowrie shells, depicted in Figure 2, were a highly successful currency across Africa, Asia, Australia, Oceana, and parts of Europe from the 13th century BCE to the early 20th century.[17] They were once so widely used in China that the symbol for cowrie shell can be found within many Chinese words involved with money.[18] Cowrie shells succeeded as a currency because they have the helpful attributes identified by economists. Durability: Cowrie shells can last for centuries and are not attractive to pests. They do not tarnish. Portability: Cowrie shells are small and light. In China they were strung into groups of 20; in Bengal they were carried in baskets of roughly 12,000.[19] Divisibility: The length of an individual cowrie shell ranges from a quarter inch to six inches and they are valued proportionately. Uniformity: As can be seen in Figure 2, cowries of a given species are remarkably consistent in shape.[20] Acceptability: Cowrie shells were accepted by common consent across much of the globe. Low storage costs: Beyond a

[11] Federal Reserve Bank of St. Louis, *op. cit*.

[12] Bagus, Philipp (2009). The quality of money. *The Quarterly Journal of Austrian Economics* 12(4): 22-45.

[13] Federal Reserve Bank of Atlanta. The story of money: 02 – Cows as a form of money. https://www.atlantafed.org/about/tours/story-of-money/02-common-products-as-money/cows-as-money.aspx.

[14] Carmody, Isolde (22 July 2012). Cows as currency. *StoryArcheology.com*. https://storyarchaeology.com/cows-as-currency/.

[15] Warner, Gregory (15 November 2017). Understanding South Sudan's cow currency is key to understanding the country's war. *NPR*. https://www.npr.org/2017/11/15/564443821/understanding-south-sudans-cow-currency-is-key-to-understanding-the-countrys-war.

[16] Fitzpatrick, Scott M. and Stephen McKeon (2020), Banking on Stone Money: Ancient Antecedents to Bitcoin. *Economic Anthropology* 7: 7-21.

[17] https://www.istockphoto.com/photo/white-cowrie-shells-gm952073298-259929937.

[18] Van Damme, Ingrid. Cowries. *Citéco: Cité de l'Économie*. https://www.citeco.fr/en/cowries-. Accessed October 3, 2021.

[19] Van Damme, *op. cit*.

[20] Van Damme, *op. cit*.

secure bit of space, cowrie shells cost nothing to store. Limited supply: Cowrie shells "occur rarely in nature"[21] and are challenging to harvest.

Figure 2: Cowrie shells

18. XRP has all of the attributes that economists agree to be valuable in a currency. Durability: Units of XRP do not rot, hold no appeal to animals, and do not tarnish. Portability: Units of XRP are effectively portable insofar as they can be accessed anywhere one finds an internet connection. Divisibility: Units of XRP are divisible because, like Bitcoin, they can be traded in decimal fractions. Uniformity: Unlike a shell, a bead, or a silver coin that must be stamped by a craftsperson and will naturally vary slightly, units of XRP are identical by construction. Each XRP comprises precisely 1 million drops, the smallest sub-unit.[22] Acceptability: XRP can be traded on myriad exchanges around the world. Low storage costs: XRP is stored in "wallets," which effectively "cost" 10 XRP (to satisfy a reserve requirement) for on-Ledger electronic repositories[23] and can be stored in hardware wallets that cost roughly the same range as a medium-quality physical wallet: $50 to $200.[24] Wallet security is high because transaction ledgers are maintained on many independent servers around the world and updated frequently. This means that the underlying record of XRP ownership is robust to physical or electronic disasters. Limited supply: The long-term supply of XRP is limited to the 100 billion already in existence. No additional units of XRP can be created without changing the XRP Ledger itself.

[21] Kusimba, *op. cit*.

[22] https://xrpl.org/xrp.html.

[23] https://xrpl.org/reserves.html.

[24] Martindale, Jon (19 July 2021). The Best Crypto Wallets for Storing Bitcoin, Ethereum, Dogecoin and More. *Forbes*. https://www.forbes.com/sites/forbes-personal-shopper/2021/07/19/best-crypto-wallet/.

18. To summarize: Experts on money have identified four major functions of a currency and a long list of attributes that foster a currency's success. XRP fulfills all these functions and has all these attributes. Consequently, XRP fully qualifies as a currency in the economic sense.

IV. Opinion on Q2: Ripple's ODL product provides an economically sound option for making cross-border and cross currency payments

A. Cross-border payments

19. Ripple's ultimate goal is to become a major hub for cross-currency payments, as it has publicly stated. As early as 2013, when the firm was quite young, Chris Larsen – a Ripple co-founder, then-CEO, and now Executive Chairman – stated that the firm's goal was "money without borders," a system in which "buyers and sellers [could] transfer money between each other more directly."[25]

20. Ripple continues to publicize its goals with respect to payments processing. To illustrate, the first item listed upon a Google search for "Ripple" is sponsored by Ripple itself and has this lead line: "Learn More About Ripple - Faster Cross-Border Payments." Next in the search results is Ripple's homepage, which states: "Ripple: Global Payment Solutions - Instant Processing." As illustrated in later paragraphs, Ripple sends this message at conferences, in the self-produced videos on its website, and in interviews by senior executives.

21. Ripple has stated that its main business strategy in the short-to-medium term is remittance payments. Worldwide remittance flows were small and largely ignored by economists and policymakers until the early 1990s, when workers began moving across borders en masse to support their families at home. By 2020, 170 million expatriate workers around the world[26] were formally remitting $540 billion to low- and middle-income economies.[27] For perspective, this is more than three times total foreign aid from all official donors, $161 billion, in that same year.[28]

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[25] Larsen presentation at the May 2013 "Finovate" conference: https://www.youtube.com/watch?app=desktop&v=t06YEtQjVvU.

[26] Guthrie, Jonathan (17 August 2021). Lex in depth – remittance fintechs herald a payments revolution. *Financial Times of London.* https://www.ft.com/content/1f11b38b-54d6-451c-ba4b-48843efa329d.

[27] World Bank (12 May 2021). Defying predictions, Remittance flows remain strong during COVID-19 crisis. https://www.worldbank.org/en/news/press-release/2021/05/12/defying-predictions-remittance-flows-remain-strong-during-covid-19-crisis.

[28] OECD (13 April 2021). COVID-19 spending helped to lift foreign aid to an all-time high in 2020 but more effort needed. https://www.oecd.org/newsroom/covid-19-spending-helped-to-lift-foreign-aid-to-an-all-time-high-in-2020-

22. A brief review of the process for a formal remittance transfer provides helpful context. A sender brings funds to a remittance service provider ("RSP") in the sender's country. This RSP, RSP ***S***, sends the funds to RSP ***R*** in the recipient's country. Finally, RSP ***R*** makes the funds available to the ultimate recipient, typically a member of the sender's family. Ripple's ODL product facilitates, and can offer faster settlements and lower costs for, transfers among RSPs, which can but need not be related institutions. A Western Union office in Hong Kong could send funds to a Western Union office in the Philippines or, alternatively, Citibank's Hong Kong subsidiary could send funds to the Bank of the Philippine Islands.

23. The outright cost of a remittance transfer is naturally higher if the source and/or recipient use physical cash (bills and coins). If the sender arrives with cash then RSP ***S*** must first convert it to digital form; if the recipient needs cash then RSP ***R*** must convert the digital funds received to cash. Dealing with cash is expensive in terms of employee time, space, and security. The additional cost of cash transfers is about 1.7% of the amount transferred, a figure that ranges across regions from 1.4% to 2.7%.[29]

24. Remittances can be sent via formal or informal channels. The four formal channels are: banks; money transfer operators such as Western Union; mobile operators such as MoneyGram; and post offices. Informal channels include foot, bus, or boat.[30] The magnitude of informal remittance flows is unknown: estimates vary from 50% to 250% of formal flows.[31] The choice between formal and informal channels is strongly influenced by the cost of remittances.[32] The total value of remittances, however, is determined primarily by family needs and resources. This means that if Ripple succeeds at bringing lower remittance costs for banks and money transfer organizations, the total flow of remittances through those channels could greatly exceed current levels.

25. One might naturally assume that, in our digital age, cross-border transactions are speedy and efficient. Indeed, debit cards have long been able to complete domestic payments within

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but-more-effort-needed.htm.

[29] World Bank (2021), *op. cit.*

[30] Cronje, Jan (10 May 2017). High bank charges force immigrants to send money home "hand-to-hand." *Ground Up*. https://www.groundup.org.za/article/high-bank-charges-force-immigrants-send-money-home-hand-hand/.

[31] Freund, Caroline and Nikola Spatafora (2008). Remittances, transaction costs, and informality. *Journal of Development Economics* 86: 346-366.

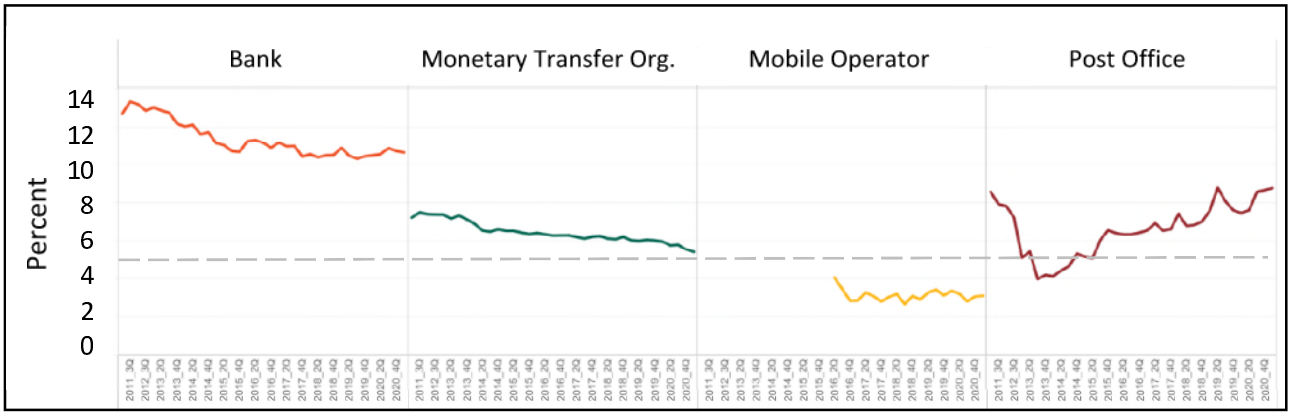
[32] Cronje (2017), *op. cit*.

minutes and at low cost. However, in the third decade of the 21st century, cross-border payments are still processed using mid-20th-century payment technologies. In consequence, remittance processing is slow, opaque, and costly. Slow: Most remittances arrive after one to 10 business days. The average speed is so slow that the World Bank considers delays of five days or less to be reasonably fast.[33] Opaque: During a standard funds transfer, neither sender nor receiver knows the status of the transfer.

26. Costly: The World Bank regularly estimates the total cost of formal remittance transfers: estimates for such costs from 2011 to the present are shown in Figure 3. In 2020, the worldwide average total cost to remit $200 by formal channels was estimated to be 6.7%.[34] (This figure includes costs to both sender and receiver. Note that it does not include the interest foregone during the delays just discussed, which is earned instead by the remittance service providers.) In that same year banks and other remittance service providers claimed at least $35 billion of the remittance money sent via formal channels to low- and middle-income countries.[35] For perspective, that represented over 20% of total official foreign aid from donors worldwide.

Figure 3: Average cost to remit $200[36]

Each figure begins in 2011:4Q and ends in 2020:4Q; dashed line represents 5% target level



[33] In selecting "smart" choices among remittance providers, the World Bank accepts any delay of five days or less. World Bank (March 2021). *Remittance prices worldwide quarterly.* https://remittanceprices.worldbank.org/sites/default/files/rpw_main_report_and_annex_q121_final.pdf.

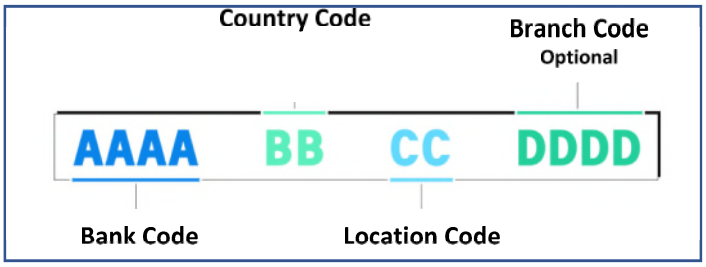
[34] *Ibid.*

[35] Arnold, Tom (12 May 2021). Remittances to developing nations resilient in 2020-World Bank. *Reuters.* https://www.reuters.com/article/health-coronavirus-remittances-int/remittances-to-developing-nations-resilient-in-2020-world-bank-idUSKBN2CT22L.

[36] *Ibid.*

27. Banks are the most expensive type of remittance service provider, as shown in Figure 3. The average cost to remit $200 via a bank was most recently estimated at 10.7%, well above the average cost across all formal remittance service providers of 6.7%.[37] The high cost of remittances via banks can be traced, in part, to their reliance on the global communications network run by SWIFT, the Society for Worldwide Interbank Financial Telecommunication. Relative to the Telex machines that preceded it, SWIFT greatly improved payment speeds and accuracy for cross-border payments in the 1970s. They did so by assigning unique identifying codes to each bank, as shown in Figure 4. The SWIFT network now includes over 10,000 banks and processes over 40 million transaction messages per day.[38]

Figure 4: SWIFT bank identification system[39]



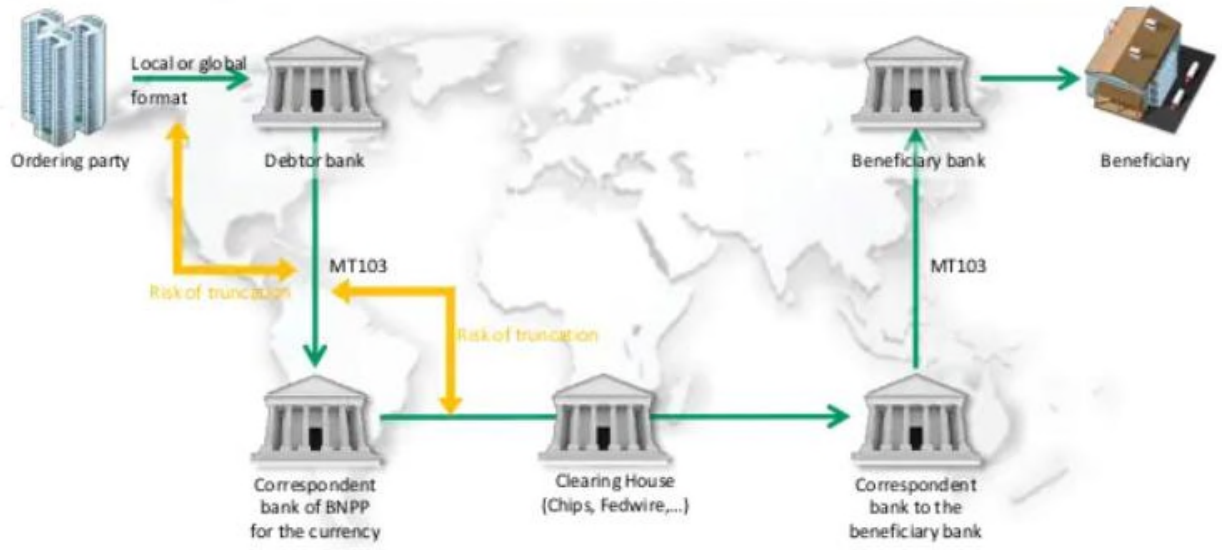
28. SWIFT only recently began to incorporate digital solutions to communication challenges. In consequence, by today's standards most cross-border remittance payments among banks are especially slow, opaque, and costly. To get from one bank to another the funds must pass through a chain of correspondent banks, as shown in Figure 5. Each bank in the chain imposes additional delays, raises the remittance cost, and increases the risk of error or misconduct.

[37] Source: World Bank (March 2021). *Remittance prices worldwide quarterly:* p. 14. https://remittanceprices.worldbank.org/sites/default/files/rpw_main_report_and_annex_q121_final.pdf.

[38] SWIFT website accessed October 3, 2021. https://www.swift.com/about-us/discover-swift/fin-traffic-figures.

[39] Sullivan, Tom (12 August 2021). What is SWIFT and what is its future? *Plaid.com.* https://plaid.com/resources/banking/what-is-swift/.

Figure 5: Correspondent chain for international payment[40]



29. In 2015 SWIFT introduced a new system known as the Global Payments Initiative ("GPI"), which is faster and substantially more transparent.[41] However, GPI remains slow relative to Ripple's ODL system because transfers through GPI still involve chains of correspondent banks.[42] GPI also remains costly because each bank in the chain must still be paid. Perhaps unsurprisingly, membership in the GPI system remains relatively limited. As of August 2021, SWIFT reported 785 member banking groups in the GPI system, less than 10% of the banks in the traditional SWIFT network.[43]

30. Ripple sees SWIFT as one of the firms it intends to challenge and has gone out of its way to publicize this message. In a November 2018 interview with Bloomberg, the current CEO, Brad Garlinghouse, stated: "What we're doing and executing on a day-by-day basis is, in fact, taking over SWIFT."[44]

[40] Yang, Eric, and Wim Grosemans (28 November 2016). An Introduction to SWIFT GPI. https://www.slideshare.net/BNPPCMCC/an-introduction-to-swift-gpi.

[41] SWIFT website. https://www.swift.com/our-solutions/swift-gpi.

[42] Westerhaus, Christian (2017). SWIFT gpi: Time for action. *Deutsche Bank Global Transaction Banking.* https://corporates.db.com/files/documents/SWIFT-gpi-Time-for-action.pdf.

[43] Sullivan, Tom (12 August, 2021). What is SWIFT and what is its future? A guide to the Society for Worldwide Interbank Financial Telecommunication (SWIFT). *Plaid.com*. https://plaid.com/resources/banking/what-is-swift/.

[44] Lam, Eric, and Haslinda Amin (13 November 2018). Ripple is aiming to overtake Swift banking network, CEO says. *Bloomberg Quint.* https://www.bloombergquint.com/technology/ripple-is-destined-to-overtake-swift-banking-network-ceo-says.

31. Ripple's goal of reducing remittance costs has long been recognized among global leaders. According to the World Bank in 2015, "Remittances contribute to sustaining the welfare of about 700 million people globally and they often represent the only source of income to provide food, healthcare, housing, and education to migrants' families."[45] Remittances can be especially important at times of crises, where a crisis could be anything from a family health emergency to major national catastrophes such as India's early-2021 COVID surge and Haiti's earthquake in August of 2021. According to Michal Rutkowski, Global Director of World Bank's Social Protection and Jobs Global Practice, "As COVID-19 still devastates families around the world, remittances continue to provide a critical lifeline for the poor and vulnerable."[46]

32. Remittance flows also promote financial development[47] and financial inclusion. "Remittances [are] … often a critical first point of entry into the regulated financial market for conventionally unbanked segments of the population."[48] Remittance transfers provide "migrants and their families … the opportunity to progressively access a more sophisticated set of financial products, such as savings, microcredit and insurances."[49]

33. In 2009, the G8 committed to reducing the cost of migrants' remittances from 10% to 5% in five years, the so-called "5x5 target."[50] In 2011, the full G20 committed to the 5x5 target at Cannes, anticipating that it would "contribut[e] to release an additional 15 billion USD per year for recipient families."[51] Though the 5% target was not reached by 2014, the G20, meeting in Brisbane that year, recommitted itself to reducing remittance costs to 5%, though they no longer

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[45] World Bank Group, Finance and Markets Global Practice (October 2015). Report on the G20 survey on de-risking in the remittance market. https://documents1.worldbank.org/curated/en/679881467993185572/pdf/101071-WP-PUBLIC-GPFI-DWG-Remittances-De-risking-Report-2015-Final-2.pdf.

[46] World Bank (12 May 2021). Defying predictions, remittance flows remain strong during COVID-19 crisis. https://www.worldbank.org/en/news/press-release/2021/05/12/defying-predictions-remittance-flows-remain-strong-during-covid-19-crisis.

[47] Giuliano, Paola, and Marta Ruiz-Arranz (2009). Remittances, financial development, and growth. *Journal of Development Economics* 90: 144-152.

[48] Global Partnership for Financial Inclusion (November 2018). 2018 Update to Leaders on Progress Towards the G20 Remittance Target. https://www.gpfi.org/sites/gpfi/files/documents/2018%20Update%20to%20Leaders%20on%20Progress%20Towards%20the%20G20%20Remittance%20Target.pdf.

[49] World Bank Group (October 2015), *op. cit.*

[50] Beck, Thorsten, and María Soledad Martínez Pería (2009). What explains the high cost of remittances: An examination across 119 country corridors. *World Bank Policy Research Working Paper* 5072. https://documents1.worldbank.org/curated/en/730331468338938197/pdf/WPS5072.pdf.

[51] G20 (4 November 2011). Cannes Summit Final Declaration – Building Our Common Future: Renewed Collective Action for the Benefit of All. http://www.g20.utoronto.ca/2011/2011-cannes-declaration-111104-en.html.

set a target date.[52] The United Nations' Sustainable Development Goals, adopted in 2015, have a more ambitious target: average remittance cost should fall to 3% by 2030, with costs below 5% in every remittance corridor.[53]

34. Global progress towards these goals has been disappointingly slow across all four formal channels, as is visible in Figure 3. At banks, which in 2011 charged on average 13% to remit $200, costs fell to around 10.5% by 2015, and then ceased declining altogether.

35. Progress on reducing costs has not been any more impressive at other formal remittance service providers. The cost of remitting $200 through a post office was near 9% in 2011 and rapidly achieved the 5% target, which might seem logical because Post Offices are under greater government control than private firms. However, the cost of remitting through a post office then began rising, in direct conflict with governments' stated aspirations, and has continued rising to its current level near 8%. The cost at money transfer operators was not far above the 5% target in 2011 and declined gradually but consistently and has essentially reached the target. The cost at mobile operators is not known for 2011 but was well below the target when data began in 2016 and has remained low.

36. The potential for a company like Ripple to compete effectively with SWIFT is a function not only of the high costs, slow speeds, and low transparency of SWIFT payments but also SWIFT's two interlocking obstacles to progress. First, a multitude of banks would earn less income from any payment system that does not require funds to flow through chains of correspondent banks. Second, SWIFT is owned and controlled by its member banks.

37. The extent to which these forces can delay a firm's adoption of new technology, even while undermining the firm's long-run viability, is clear from the New York Stock Exchange's ("NYSE") long-delayed adoption of electronic trading. For most of the 20th century the NYSE dominated US stock issuance and trading with a system that relied on "specialists" on the floor of the exchange. Crucially, those specialists also owned the exchange. During the late 1980s and 1990s, electronic trading systems were developed that proved highly attractive to traders. Stock exchanges around the world began switching to all-electronic trading in the 1990s: the Toronto

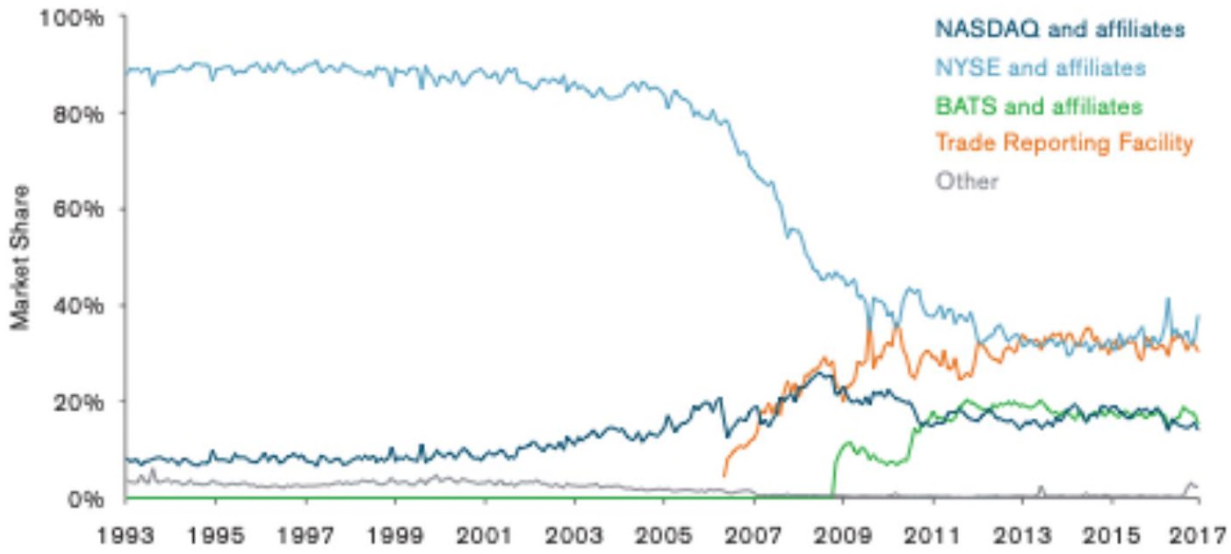
[52] G20 Leaders' Communiqué, Brisbane Summit, 15-16 November 2014. https://www.mofa.go.jp/files/000059841.pdf.

[53] UN Department of Economic and Social Affairs. The 17 goals. (Goal 10c.) https://sdgs.un.org/goals.

Stock Exchange, for example, closed its trading floor and implemented an electronic trading platform in 1997. Closer to home, new electronic exchanges emerged in the U.S. and began siphoning NYSE's market share.

38. The NYSE's specialists had become obsolete, in essence. However, they were still profitable and reluctant to adopt a trading system in which they would have little role, much like the banks that participate in remittances today. The specialists resisted any move towards electronic trading, which compromised the exchange's long-run success. From 2001 through 2007 the NYSE's market share collapsed from roughly 87% to roughly 50%, as shown in Figure 6. The NYSE eventually solved this conundrum by going public, which meant the specialists could monetize their seats. The damage done through delay proved lasting, however: the once-dominant exchange's market share continued to decline through 2012, and subsequently stabilized at roughly 35%.

Figure 6: Market shares among U.S. stock exchanges[54]

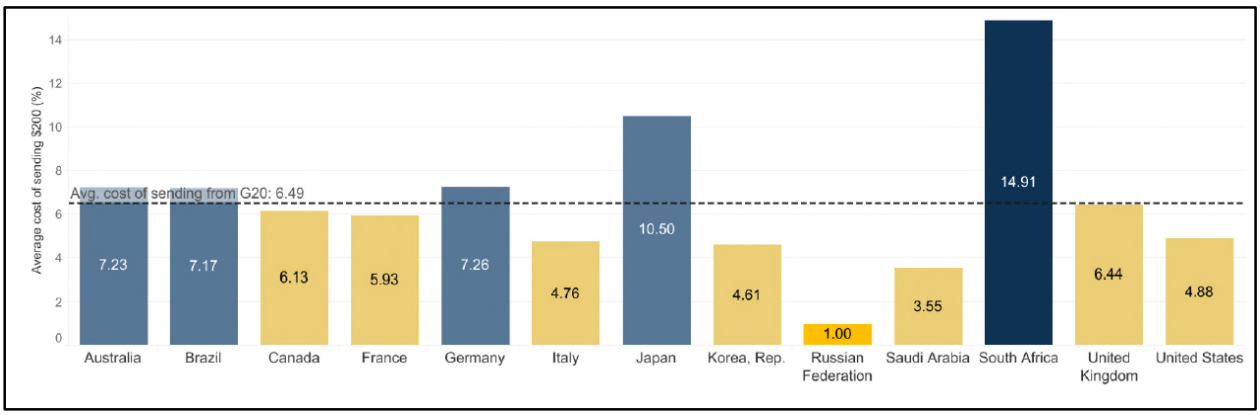


39. Despite the world's slow progress in reducing remittance costs, there have been pockets of success. Digital transfer systems clearly have an advantage in lowering costs. Figure 3 shows that it is least costly to remit $200 via mobile operators, which are digital by design. Confirmation that remittance costs can be reduced dramatically comes from Russia, whose 1%

[54] Moolji, Amyn, and Briand Smith (October 2017). A financial system that creates economic opportunities: Capital markets. *U.S. Department of the Treasury*: p. 53. https://www.treasury.gov/press-center/press-releases/Documents/A-Financial-System-Capital-Markets-FINAL-FINAL.pdf

average total cost to remit $200 is far below the average total cost in other G20 countries, as shown in Figure 7 (as a reminder, the total cost combines costs to sender and receiver).

Figure 7: Average total cost of remittances, 13 of the G20 countries[55]



40. Ripple is not the only firm to recognize the potential for profits from using a blockchain platform for remittance processing, though it was among the first. Other start-ups pursuing this market segment include Currency Cloud[56] and Earthport[57] (now owned by Visa).[58]

41. Ripple has achieved significant progress towards its goals of becoming a significant competitor among remittance service providers. By 2015 many of the world's biggest banks had joined Ripple's Global Payments Steering Group as founding members. The group's intent is "to use Ripple's technology to slash the time and cost of settlement while enabling new types of high-volume, low-value global transactions."[59] ("Settlement" refers to the actual process of moving funds.) Original members include Bank of America Merrill Lynch, Japan's MUFG Bank (formed via mergers of five commercial banks during 1996-2002), Standard Chartered Bank, Westpac, and Banco Santander.

42. Though only commercially available since 2019, I understand that ODL has customers in locations as diverse as the near-east, Latin America, and Asia's Pacific Rim. It has achieved the

[55] Source: World Bank (March 2021), *op. cit.*, p. 12.

[56] https://www.currencycloud.com/global-payments-for-fintech-platforms.

[57] https://www.thepower50.com/profiles/earthport/

[58] PYMNTS (15 May 2019). Why Visa brought Earthport into its orbit. https://www.pymnts.com/visa/2019/earthport-acquisition-cross-border-payments/.

[59] Finextra.com (28 September 2016). Ripple rudely gatecrashes Sibos party. https://www.finextra.com/newsarticle/29512/ripple-rudely-gatecrashes-sibos-party.

greatest growth in the latter region, which is economically logical because payments systems there have been more advanced than in the "advanced economies" for over a decade. Among Ripple's clients or ODL partners is Tranglo in Malaysia,[60] Coins.ph in the Philippines, at least two remittance service providers in South Korea (Sentbe and CoinOne), and SBI Remit in Japan.[61] SBI, one of Japan's largest banks, is a natural partner for Ripple because it is young and tech-savvy and growing rapidly; it did not even exist before 1999.

43. Ripple's long-run strategic goals extend well beyond remittances. The firm's ambition is to modernize international payments. In the firm's own words, its goal is "[e]nabling the world to move value like it moves information today."[62] This goal encompasses the payments associated with international trade in goods and services. In 2020 these were worth $17.6 trillion, over thirty times the value of remittance flows, and the bulk of these payments were necessarily facilitated by the SWIFT system of the banks.[63] Payment for international trade has been identified by multiple firms as a potentially lucrative market for innovative protocols. IBM has developed its own blockchain and embedded it in the trade finance network We.trade.[64] Other challengers to SWIFT's dominance in payments for international trade are government sponsored, including Instex (EU),[65] CIPS (China),[66] and SPFS (Russia).[67]

44. Ripple's ODL service is designed to provide a cost-effective and efficient alternative to the cross-border payments market. As explained below, ODL provides fast, secure, transparent, and low-cost cross-border and cross-currency payments. Customers licensing ODL from Ripple use XRP to make cross-border and cross-currency payments "in as little as three seconds," which allows them to eliminate pre-funding of destination accounts, reduce operations costs, and unlock capital.[68] In my opinion, for the reasons explained below, the ODL system is superior to

[60] Tranglo (9 April 2021). Tranglo levels up with Ripple to power cross-border payments in Southeast Asia. https://tranglo.com/blog/tranglo-levels-up-with-ripple-to-power-cross-border-payments-in-southeast-asia/.
[61] Ripple (25 February 2020). Ripple on full-scale to tap into South Korean market. https://ripple.com/ripple-press/ripple-on-full-scale-to-tap-into-south-korean-market/.
[62] https://ripple.com/company.
[63] Statista. Trends in global export value of trade in goods from 1950 to 2020. https://www.statista.com/statistics/264682/worldwide-export-volume-in-the-trade-since-1950/.
[64] IBM. What are smart contracts on blockchain? https://www.ibm.com/topics/smart-contracts.
[65] https://instex-europe.com/about-us/.
[66] https://www.cips.com.cn/cipsen/7052/7057/index.html.
[67] http://www.cbr.ru/eng/psystem/fin_msg_transfer_system/.
[68] https://ripple.com/ripplenet/on-demand-liquidity/.

existing cross-border payment systems and therefore a viable competitor. Relative to current payment systems with fiat money, ODL is faster, more transparent, and less costly. Relative to the dominant cryptocurrency ledger systems, the XRP Ledger is faster, less costly, equally transparent, and less resource-intensive.

B. Innovative technology

45. ODL, at its core, leverages the XRP Ledger, a blockchain ledger system for recording and verifying transactions. Complete records of all transactions – "ledgers" – are simultaneously maintained on many computers, typically located worldwide. As transactions arrive, they are verified individually or in a group ("block") by these same computers.

46. The decentralized nature of a blockchain reflects the commitment among the founders of Bitcoin and other cryptocurrencies to avoiding central control. Even so, like any monetary system, these systems must be trusted to succeed. Fiat currency systems are trusted in part because they have state sponsorship. In addition, residents learn through experience that their local monetary institutions can be trusted: commercial banks, savings banks, and the central bank successfully collaborate to provide accurate and timely payments. A decentralized currency system must generate trust as well, and a common approach for new cryptocurrencies is to implement and publicize a technology that assures fast and accurate payments.[69]

47. For blockchain ledgers, a major requirement for trust is a solution to the "double-spend" problem:

> Decentralized cryptocurrency networks need to make sure that nobody spends the same money twice without a central authority like Visa or PayPal in the middle. To accomplish this, networks use something called a "consensus mechanism," which is a system that allows all the computers in a crypto network to agree about which transactions are legitimate.[70]

48. Computers can be taken over by corrupt parties, and falsely label invalid transactions as valid. A consensus mechanism identifies when the signals from a set of computers can be

[69] Andrews, Edmund L. (24 September 2013). Chris Larsen: Money without borders. *Insights by Stanford Graduate School of Business*. https://www.gsb.stanford.edu/insights/chris-larsen-money-without-borders.

[70] Coinbase. What is "proof of work" or "proof of stake"? Accessed October 3, 2021. https://www.coinbase.com/tr/learn/crypto-basics/what-is-proof-of-work-or-proof-of-stake.

trusted. This represents a version of the "Byzantine Generals Problem" in computer science: How can one verify information from multiple sources, without knowing which are trustworthy?

49. Bitcoin pioneered the most common solution to the Byzantine Generals Problem among cryptocurrencies in a protocol known as "proof-of-work." In essence, computers seeking to verify a given block of transactions are given a processing challenge that almost invariably requires a lot of time and computing power. The first computer to solve the challenge is rewarded with a small number of Bitcoins, potentially worth hundreds of thousands of dollars at current prices. The challenge, known as "mining," involves putting numbers chosen largely at random through a special mathematical function until a sufficiently small outcome is generated.[71]

50. Proof-of-work transaction verification, though reliable and transparent, is slow and expensive by digital standards and resource-intensive by any standard. Slow: The average time to verify a Bitcoin transaction is generally about ten minutes, as shown in Figure 8. The time occasionally rises when transaction volumes are high, as happened when the price fell dramatically in May of 2021. Ten minutes is certainly speedy relative to the days or weeks required for traditional currency conversion channels. However, time is now measured in microseconds in financial markets, which makes even ten minutes an extremely long time. If each microsecond were a full second, a "ten-minute delay" would be 57 years. Expensive: As shown in Figure 9, Bitcoin transaction fees over approximately the past year have been at least $2 and can range up to $60 per transaction. As discussed below in paragraphs 51-54, this is many multiples of the cost per transaction on the XRP Ledger, and a major contributor is the cost of computing resources (electricity and dedicated mining computers).

[71] For details, *see* Foley, Maxwell (12 September 2019). How Bitcoin works: Hashing. *Certick*. https://medium.com/certik/how-bitcoin-works-hashing-e897157f7940.

Figure 8: Bitcoin Average Confirmation Time[72]

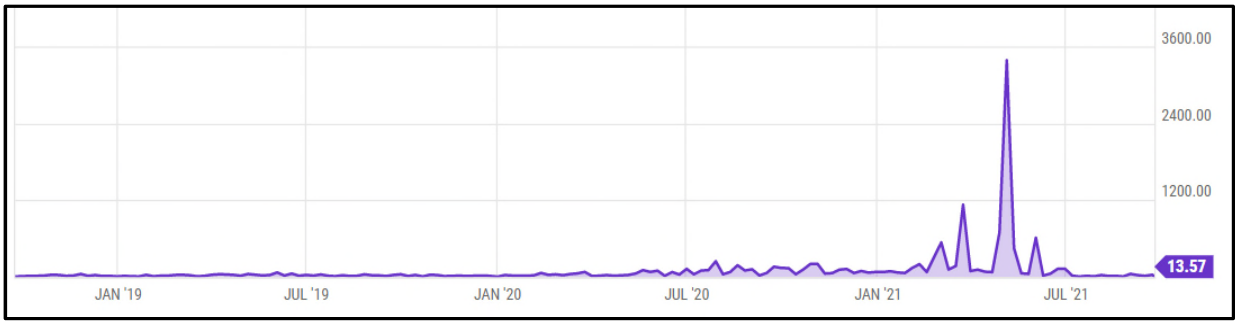
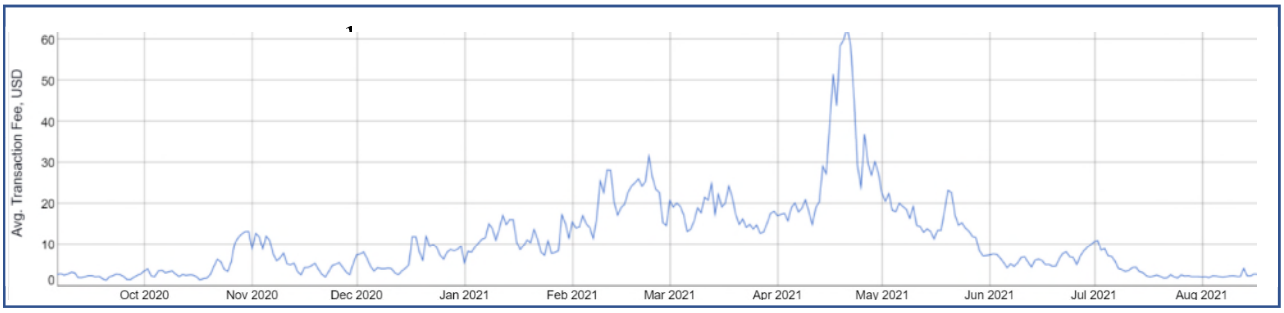


Figure 9: Average transaction fees for Bitcoin over 12 months[73]



51. Resource intensive: It would be natural to assume that Bitcoin's 10- to 60-minute average verification time – and the amount of resources required to verify Bitcoin transactions using proof-of-work – would decline as computers become more powerful. This is not the case, however. It *is* true that every advance in computer sophistication provides the first miners to exploit it with an advantage over their peers. However, that first-mover advantage is fleeting because other miners quickly upgrade their computers. It is estimated that computers dedicated to Bitcoin mining are used for only 1.3 years, on average – and because they are tailored to that purpose they cannot be used for others. In consequence, Bitcoin miners collectively generate as much physical electronic waste (e-waste) as the Netherlands, and little of it is recycled.[74]

52. Rising computer speeds also do not reduce the energy-intensity of Bitcoin mining. To ensure that just 2,016 new bitcoin are put in circulation every two weeks, the ledger system is

[72] Source: https://ycharts.com/indicators/bitcoin_average_confirmation_time.

[73] Source: https://bitinfocharts.com/comparison/bitcoin-transactionfees.html#1y. Accessed September 7, 2021.

[74] BBC News (September 2020). Bitcoin mining producing tonnes of waste. https://www.bbc.com/news/technology-58572385.

programmed to track the average time required to verify a block and, whenever that time declines, to increase the difficulty of verification.[75] By 2018 verifying a single Bitcoin transaction required 80,000 times the electricity as a single Visa credit card transaction.[76] In 2019 the Bitcoin blockchain system alone consumed approximately as much energy, and generated as many carbon emissions, as the economies of Jordan or Sri Lanka.[77]

53. The XRP Ledger does not use proof-of-work verification. Instead, it relies on a "consensus protocol." The consensus mechanism in the XRP Ledger is faster, less costly, and less energy-intensive than proof-of-work because its solution to the Byzantine Generals Problem is based on voting. Each computer in the XRP Ledger specifies a set of other network computers whose votes it will consider. A transaction is verified if it is confirmed by a sufficient share of computers in that set. The critical share is determined mathematically to guarantee accuracy even if some members of the set are corrupt.

54. The performance of XRP Ledger is striking. Speed: The XRP Ledger's verification protocol requires just a few seconds, less than 1% of the 10 minutes required by proof-of-work.[78] Cost: The cost to transact on the XRP Ledger is well below the cost of a Bitcoin transaction. The cost for any XRP Ledger transaction is fixed at 0.00001 XRP; at the current USD-XRP exchange rate this is worth about $0.00001 (1/1000th of a cent). A Bitcoin transaction fee of $10 (which appears to be a bit below the average of the past year, according to Figure 9) would be roughly 1 million times the cost of an XRP transaction.[79] For perspective, a tall oak tree is roughly one million times the height of half a grain of sand. Resource intensity: The voting protocol on the XRP Ledger requires less than 0.002% of the computing power required by proof-of-work.[80] There is no gain to be anticipated from applying greater computing power.

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[75] Rosenfeld, Meni (2016). How many zeros should I require for proof-of-work and how should this change through the years? https://www.quora.com/How-many-zeros-should-I-require-for-proof-of-work-and-how-should-this-change-through-the-years.

[76] Popper, Nathaniel (21 January 2018). There is nothing virtual about Bitcoin's energy appetite. *New York Times.* https://www.nytimes.com/2018/01/21/technology/bitcoin-mining-energy-consumption.html?searchResultPosition=1.

[77] Smith, Alexander (13 May 2021). Factbox: How big is Bitcoin's carbon footprint? *Reuters*. https://www.reuters.com/technology/how-big-is-bitcoins-carbon-footprint-2021-05-13/.

[78] https://xrpl.org/xrp-ledger-overview.html.

[79] https://bitinfocharts.com/comparison/bitcoin-transactionfees.html#1y.

[80] Schwartz, David (8 July 2020). The Environmental Impact: Cryptocurrency Mining vs. Consensus. https://ripple.com/insights/the-environmental-impact-cryptocurrency-mining-vs-consensus/.

55. A further advantage of the XRP Ledger relative to the Bitcoin proof-of-work ledger is **scalability**, meaning the ability to handle a high number of transactions per period. On average just 4.6 transactions per second can be processed on the Bitcoin ledger, a limit that is essentially programmed into the ledger. The goal of the limit is important: protecting the system against the possibility that someone with ill intent might spam the system by sending a massive number of transactions through the system at once, slowing the system down, and effectively crowd out other transactions. Ether can handle 30 transactions per second.[81] The XRP Ledger has had far greater capacity for years – it could handle 500 transactions per second in 2015.[82] By now it can readily process 1,500 transactions per second.[83]

56. Given the high cost of proof-of-work verification, Ether and a few other crypto-currency platforms are shifting to a newer solution to the Byzantine Generals Problem. In this "proof-of-stake" system, transaction verifiers must set aside or "stake" a substantial quantity of the platform's native currency (*e.g.*, Ether on the Ethereum platform). A greater stake brings higher odds of being included as a verifying party and, crucially, the amount of native currency received in compensation when that happens. To further enhance security, verifiers lose part of their stake if a bad transaction is verified.[84] Proof-of-stake has lower transaction costs than proof-of-work and imposes lower costs on the environment. Nonetheless, a proof-of-stake transaction will be more costly than a transaction over the XRP Ledger because the former requires substantial resources to be set aside (and be paid in case of a false verification) that could otherwise be earning income.

C. XRP is a logical solution to well-known challenges in cross-currency conversion

57. From an economic perspective, the features of XRP and the XRP Ledger are well suited to the ODL product. Any cross-border transaction processing network, including today's foreign exchange ("FX") market, faces a major challenge from the multiplicity of currencies. The United

[81]Conway, Luke (1 September 2021). What is Ethereum 2.0? *The Street*. https://www.thestreet.com/crypto/ethereum/ethereum-2-upgrade-what-you-need-to-know.

[82] Travis, Mark (2 October 2017). Ripple: The most (demonstrably) scalable blockchain. *High Scalability*. http://highscalability.com/blog/2017/10/2/ripple-the-most-demonstrably-scalable-blockchain.html.

[83] Bhalla, Anshika. Top cryptocurrencies with their high transaction speeds. *The Blockchain Council*. https://www.blockchain-council.org/cryptocurrency/top-cryptocurrencies-with-their-high-transaction-speeds/.

[84] Coinbase, *op. cit.*

Nations lists 195 sovereign countries in the world, with 154 "operational" currencies.[85] Suppose that every unique national currency could be converted directly to every other one: Omani rial could be converted directly to Cambodian riel, Colombian pesos could be converted directly to Ugandan shillings. There would be 11,628 unique exchange rates, each of which would be changing frequently during every day. To ensure they offer appropriate exchange rates when a client reaches out to trade, dealing banks would have to actively monitor each exchange rate, which would require massive and expensive staffing. Trading rooms would hire hundreds of new dealers, each of them requiring significant salaries plus bonuses, and each bank's electronic trading staff would likewise expand to generate and stream up-to-the-microsecond values for each exchange rate. There would be commensurate increases in back-office staff – those involved in settlement, risk, and compliance.

58. The extreme multiplicity of country pairs and exchange rates has been a challenge to the FX market for roughly two centuries. Throughout that period a single solution has been consistently adopted: a vehicle (or bridge) currency. Suppose V is the vehicle currency. Conversion of, say, Colombian pesos to Ugandan shillings involves two transactions: (1) a purchase of V with pesos; (2) a sale of V for shillings.[86] Though it involves two transactions rather than one, this system of indirect currency conversion proves to be less costly than having 11,000+ directly-traded currency pairs. In addition to the labor savings, when trading is concentrated in a relatively small number of currency pairs the liquidity of each traded pair increases sufficiently to reduce total transaction costs.

59. The world's first vehicle currency was the pound sterling, which acquired that role in the 19th century when the UK dominated world trade and finance. After WWI the vehicle-currency function began shifting to the US dollar. By the end of WWII, when the Bretton Woods system of fixed exchange rates was adopted, the US dominated world trade and finance so the dollar became the only vehicle currency. The euro, created in 1999, has become a vehicle currency for a few fiat currencies from countries adjacent to the European Monetary Zone (*e.g.*, the

[85] United Nations. UN Operational Rates of Exchange. https://treasury.un.org/operationalrates/OperationalRates.php.

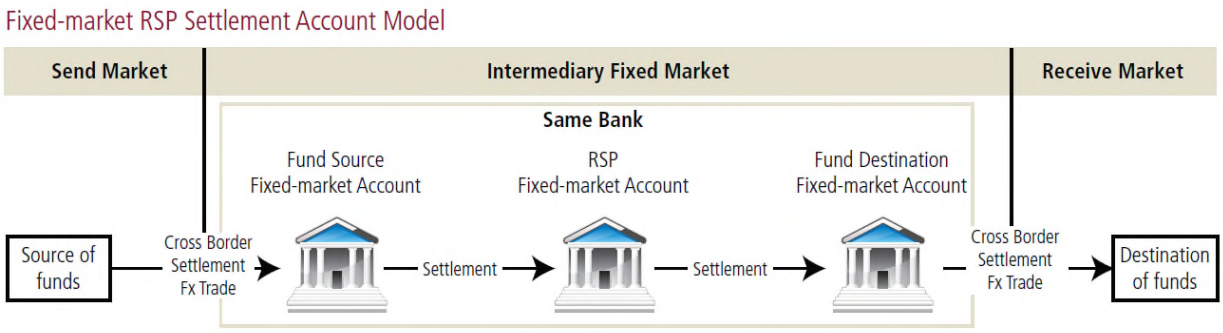
[86] Vehicle currencies have long been a subject of research in economics. Notable contributions from the past 40 years include: Magee, Stephen P., and Ramesh K. Rao (1980). Vehicle and nonvehicle currencies in international trade. *American Economic Review* 70(2): 368-373.

Devereux, Michael B., and Shouyong Shi (2013). Vehicle Currency. *International Economic Review* 54(1): 97-133.

Norwegian krone). China seeks to develop this function for its currency, known as the yuan or the renminbi.

60. A vehicle-currency system has also proved valuable for digital transactions. Some mobile remittance service providers adopt a "fixed-market [remittance service provider] settlement accounts model," depicted in Figure 10, which is, in essence, a vehicle-currency system. The sender's currency, whatever it may be, is traded into the currency of a specific "intermediary" market. This amount is then converted by local banks into the receiver's currency and moved to the destination country. The "intermediary" currency is effectively a vehicle currency.

Figure 10: Using a vehicle currency to process remittances[87]



61. The XRP Ledger can be used to facilitate payments across not just fiat currencies, but also cryptocurrencies. As of August, 2021 there were 5,840 cryptocurrencies in existence.[88] To provide direct convertibility for all pairs of fiat and crypto currencies would involve tracking and verifying exchange rates across 17,955,028 unique currency pairs. A vehicle currency system reduces that figure by 99.97%.

62. So far, this section has discussed the logic behind using a vehicle currency to streamline currency conversions. Ripple also had to decide on a specific currency to perform that function. Critically, today's fiat currencies could be immediately ruled out because FX transactions in fiat currencies currently take days to settle. In the wholesale FX markets settlement requires two

[87] Daly, Neil (May 2010). International remittance service providers. *GSMA Mobile Money Transfer*: p. 7. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2012/03/gsmaremittanceserviceproviderwhitepaper182.pdf.

[88] Source: Statista. Number of cryptocurrencies worldwide from 2013 to August 2021. https://www.statista.com/statistics/863917/number-crypto-coins-tokens/. Accessed August 24, 2021.

business days[89] during which each counterparty contacts the other, verifies trade specifics, and exchanges information about bank accounts and the like. This makes fiat currencies unsuitable for payments that are designed to process in real time, meaning settlement happens within minutes of the initial trade (the initial agreement to exchange certain assets at a certain price). In contrast, the XRP Ledger is designed to achieve real-time settlement, and XRP is the native currency of the XRP Ledger.

63. The most efficient cryptocurrency on any decentralized platform is one that is carefully designed to fulfill that platform's intended purpose. The software behind Bitcoin and the vast majority of other cryptocurrencies is not designed to facilitate efficient payments from a holder of one fiat currency to the holder of another fiat currency. That, however, is precisely the purpose of the XRP Ledger, and XRP is the specially-designed or "native" currency of the XRP Ledger. XRP therefore maximizes the efficiency of the XRP Ledger which, in turn, minimizes the cost of Ledger transactions.

64. To summarize: the XRP Ledger relies on a vehicle currency to reduce the number of active currency pairs to a manageable level, the same solution adopted for two centuries in the FX market. ODL is intended to achieve settlement in real time and therefore cannot rely on a fiat currency as vehicle currency, because fiat currencies require two days to settle. ODL therefore relies on the XRP Ledger's native currency, XRP, to serve as vehicle currency.

D. Disruptive innovation

65. The competitive viability of ODL leveraging the XRP Ledger is supported by Ripple's choice of global strategy. Economic theory suggests that a firm with superior technology but fewer resources than the currently-dominant firms will wisely adopt the strategy known as "disruptive innovation." The relevance of this strategy is immediately apparent from this description by the economists who first outlined this strategy:

> "Disruption" describes a process whereby a smaller company with fewer resources is able to successfully challenge established incumbent businesses. Specifically, as incumbents focus on improving their products and services for their most demanding (and usually most profitable) customers, they exceed the needs of some segments and

[89] There is one exception to this two-day rule: just one business day is required to settle trades between the US and Canadian dollars.

> ignore the needs of others. Entrants that prove disruptive begin by successfully targeting those overlooked segments, gaining a foothold by delivering more-suitable functionality—frequently at a lower price. Incumbents, chasing higher profitability in more-demanding segments, tend not to respond vigorously. Entrants then move upmarket, delivering the performance that incumbents' mainstream customers require, while preserving the advantages that drove their early success. When mainstream customers start adopting the entrants' offerings in volume, disruption has occurred.[90]

66. Amazon provides a classic example of disruptive innovation. Amazon began as a small online bookseller. Its technology proved so successful that it quickly gathered market share from many brick-and-mortar book retailers, including large chain book sellers. Amazon used that experience to refine its systems for marketing, inventory management, payment, and shipment, and then went on to disrupt retail markets in many other products. By now almost anything tangible and reasonably portable can be purchased through Amazon, including groceries, streamed movies, and furniture.

67. Like Amazon when it started, Ripple fulfills the economic conditions that make disruptive innovation an appropriate strategy. It has a product that provides improved functionality at faster speeds and lower costs than incumbent products. As a start-up it has far fewer resources than incumbents such as SWIFT or Western Union.

68. Ripple's actions conform to the disruptive innovation strategy. The firm has focused on remittances, which is not a core business for most banks, and has avoided challenging the dominant payments systems head-on. It has collaborated with big banks on prototype digital payment systems rather than compete directly with SWIFT. Likewise, Ripple has intentionally avoided any direct challenge to the dominant money transfer operator, Western Union, as stated explicitly by David Schwartz, Ripple's Chief Technology Officer, in 2016.[91]

69. Gaining market share with a disruptive product that must ultimately create a network to thrive is extremely challenging. The reason is that the network of a dominant firm creates an almost insurmountable "barrier to entry" for challengers. SWIFT, with its network of over 10,000 banks worldwide, provides an apt illustration of a phenomenon known in economics as

[90] Christensen, Clayton, Michael E. Raynor, and Rory McDonald (December 2015). What is disruptive innovation? *Harvard Business Review*: 44–53. https://hbr.org/2015/12/what-is-disruptive-innovation.

[91] Ripple Live: Ask me anything with David Schwartz (21 December 2017). https://www.youtube.com/watch?v=NNuu7NIJAN4.

"network externalities." SWIFT's network gives it an advantage (or "positive externality") as the firm seeks new member banks. Any non-member bank can be confident that a SWIFT membership will make it easy and profitable to send funds to banks in a myriad of locations.

70. Economists would say that a dominant firm with an established network is "highly defensible" because it is extremely difficult to challenge them, even for a firm with far better products.[92] The challenger needs a network to attract clients, but without clients there is no network. Further, the dominant firm can set up additional roadblocks by giving second-class treatment to network members that collaborate with a challenger.

71. Some of Ripple's key strategic moves to date seem directly aimed at finding a route past the barricades associated with network externalities. Its 2019 commitment of up to $50 million to seed a partnership with Moneygram was likely intended to seed or jumpstart the necessary network. With this agreement in hand, Ripple could make a stronger case with other potential partners. For example, Ripple's choice to focus on one region, Asia's Pacific Rim, can be seen as leveraging that seed to create a strong network in one region. Many of the clients that Ripple has gained in this region are relatively small and focus on a narrow set of remittance "corridors." Coins.ph is focused on Philippine clients and, one infers, remittances into the Philippines; Siam Commercial Bank focuses on clients in Thailand; SBI Remit in Japan is focused on remittances from Japan. Such clients would benefit from ODL in their remittance corridors but do not need it to be available in all others. The network Ripple is creating in the Pacific Rim includes ties to countries in other regions including Latin America, and Africa. In theory those ties could next be leveraged to reinforce its still-limited links to one or more of those other regions. There is no rush, however. According to experts on the disruptive innovation strategy, "a headlong rush to fast growth is often unnecessary and can even backfire…"[93]

72. I understand that the SEC has argued that ODL is unprofitable or earns Ripple only *de minimis* revenue.[94] Assuming that is true, it provides no information on the firm's ability to compete as a payments service provider using ODL. Put differently, ODL can be (and in my opinion is) a viable option for making cross-border payments even if it is not currently profitable.

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[92] Haiglu, Andrei, and Simon Rothman (April 2016). Disruptive innovation: Network effects aren't enough. *Harvard Business Review:* 65-71. https://hbr.org/2016/04/network-effects-arent-enough.

[93] *Ibid.,* p. 65.

[94] Amended Complaint, ¶ 374.

Young technology-driven firms that must build networks often take many years to reach profitability. Airbnb, established in 2008, did not become profitable until 2020 and then returned to losses in 2021.[95] Uber, founded in 2009, is not yet profitable.[96] Pinterest, also established in 2009, may have finally reached profitability in 2021.[97] However, the viability of a start-up is not evaluated according to its profitability: Airbnb is currently worth $105 billion, Uber is worth $89 billion, and Pinterest is worth $34 billion. Indeed, profitability eluded over 80% of the firms that launched initial public offerings during the first three quarters of 2018.[98]

73. Profitable or not, Ripple is certainly getting noticed as a market disruptor. In 2020 CNBC listed Ripple as 28th on its list of the top 50 "Disruptor" firms, citing specifically the ODL service and XRP.[99]

74. To summarize this section, Ripple is a start-up with an innovative platform for cross-currency payments, ODL, that makes transfers more rapidly, at lower cost, and with greater transparency than existing platforms. The firm hews closely to the economically-logical strategy for firms in this situation, disruptive innovation. It faces massive barriers to entry, however, because it is attempting to disrupt an industry in which network externalities are substantial. Consistent with the principle of disruptive innovation, Ripple has so far avoided direct challenges to the dominant players by focusing on relatively small or new segments of the payments industry. The firm has always been clear, however, that its ultimate goal is to remake the $2 trillion business of payments processing.

[95] https://finance.yahoo.com/quote/ABNB/. Market capitalization as of 1 October 2021.

[96] https://finance.yahoo.com/quote/UBER/. Market capitalization as of 1 October 2021.

[97] https://finance.yahoo.com/quote/PINS?p=PINS&.tsrc=fin-srch. Market capitalization as of 1 October 2021.

[98] Cremades, Alejandro (4 December 2018). Profit vs growth: How to select the right strategy for your business. *Forbes*. https://www.forbes.com/sites/alejandrocremades/2018/12/04/profit-vs-growth-how-to-select-the-right-strategy-for-your-business/?sh=54b023a1410e.

[99] CNBC.com Staff (16 June 2020). *Disruptor 50 2020*. https://www.cnbc.com/2020/06/16/ripple-disruptor-50.html.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on October 4, 2021

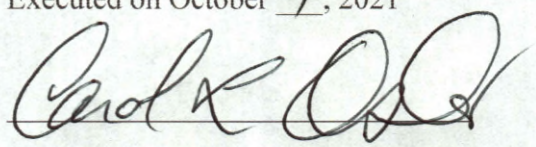

Exhibit A

Carol Osler, Ph.D.
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BIO

Carol Osler, Ph.D. is the Martin and Ahuva Gross Professor of Financial Markets and Institutions at the International Business School of Brandeis University. Dr. Osler's research focuses on exchange rates and foreign exchange trading. She has also recently published research on workplace bullying. Dr. Osler's courses cover behavioral finance, financial market structure and the trading process, and applied macroeconomic analysis. Dr. Osler's legal consulting engagements have the foreign exchange, bond, and precious-metals markets.

Dr. Osler served as research economist at the Federal Reserve Bank of New York and has also taught at the Norwegian School of Business (BI), the Amos Tuck School of Business at Dartmouth College, the Kellogg School of Management at Northwestern University, Columbia University, and the Massachusetts Correctional Institution at Concord.

EDUCATION

Ph.D., Economics: Princeton University
M.A., Economics: Princeton University
BA: Swarthmore College

PROFESSIONAL EXPERIENCE

ACADEMIC ENGAGEMENTS

PRESENT:	Martin and Ahuva Gross Professor of Financial Markets and Institutions, Brandeis International Business School, Brandeis University
2019	Taught basic finance to prisoners at MCI Concord, MA.
2002-2013	Associate Professor of Finance and Economics, Brandeis International Business School
1991-2002	Federal Reserve Bank of New York. Capital Markets Division of Research and Market Analysis Group. Senior Economist
1994	Visiting Economist, Foreign Exchange Trading Desk, Federal Reserve Bank of New York
1993-1996	Columbia University, Adjunct Assistant Professor of Economics.
1990-1991	Kellogg School of Management, Visiting Assistant Professor of Finance.
1988	NBER Ford Foundation Fellow
1985-1991	Assistant Professor, Amos Tuck School of Business Administration, Dartmouth College.

EXPERT RETENTIONS

2019-PRESENT *Joseph S. Mancinelli et al. v. Bank of America et al.*, Ontario Superior Court of Justice (SSA Bonds)

2018-PRESENT *Julius di Filippo and David Caron v. Bank of Nova Scotia et al.,* Ontario Superior Court of Justice (Silver)

2017-PRESENT *Julius di Filippo and David Caron v. Bank of Nova Scotia et al.,* Ontario Superior Court of Justice (Gold)

2017-PRESENT Maurice Blackburn Pty Ltd., Melbourne, Australia. Economic consultant on FX antitrust suit (FX).

2018 *Axiom Investment Advisors, LLC, v. Deutsche Bank AG*. US Southern District of New York.

2018 *James Contant, et al., v. Bank of America Corporation, et al.,* US District Court, Southern District of New York (Indirect FX)

2016-PRESENT *Chris Staines v. Royal Bank of Canada et al., Defendants*, Ontario Superior Court of Justice (FX)

2018 *Axiom Investment Advisors, L.L.C. v. Deutsche Bank AG*, US District Court, Southern District of New York (FX: Last look)

2015-2016 U.S. Department of Justice action on price-fixing conspiracy in FX markets

2014 Lovell Stewart Halebian Jacobson L.L.P. Preliminary work towards class-action complaint on price-fixing conspiracy in FX markets

2011-2012 Consultant for Charles River Associates in their support of State Street Bank in *People of the State of California v. State Street et al.,* Superior Court of the State of California County of Sacramento.

ADMINISTRATION

2021-2022: Chair, Brandeis Faculty Senate

2019 – 2021: Member, Faculty Senate and Faculty Senate Council, Brandeis University

2020 – 2021: Library Advisory Committee

2019: Co-facilitator, Course Design Workshop, Brandeis Center for Teaching and Learning

2016 – 2020: Co-Chair, Dignity at Work Task Force of the Faculty Senate, Brandeis University

2015: Chair, Provost Search Committee, Brandeis University

2010 – 2018: Chair, University Budget Committee, Standing Committee of Brandeis University.

2009 – 2012: Member, Faculty Senate Council, Brandeis University

2008 – 2015: Program Director, Master of Arts in International Economics and Finance, Brandeis International Business School

2007-2008: Acting Program Director, Ph.D. Program, Brandeis International Business School

Chair and member of numerous search committees including those for presidential direct reports and other senior administrators. Member and chair of committees on undergraduate mental health, tenure and promotion committees, contract review committees, etc.

RESEARCH

PUBLICATIONS

Workplace Bullying: Nature, Consequences, and Recommended Policies. *Journal of Organizational Psychology* 21(2).

Price Discovery in Two-tier Markets, joint with Geir H. Bjønnes and Dagfinn Rime (2021). *International Journal of Finance and Economics* 26(2): 3109-3133.

The Market Microstructure Approach to Foreign Exchange: Looking Back and Looking Forward, joint with Michael King and Dagfinn Rime (2013). *Journal of International Money and Finance* 38 (November): 95-119.

The Microstructure of Currency Markets: Market Microstructure in Emerging and Developed Markets (2013), with Xuhang Wang. Chapter 5 in: Ed. Kent Baker and Halil Kiymaz, Eds. (John Wiley, Inc.: New York and London).

Currency Market Microstructure and the Profitability of Currency Trading (2012). *Annual Review of Financial Economics* 4: 469-495.

Noise Trading and Illusory Correlations in US Equity Markets, joint with Jennifer Bender and David Simon (2012). *Review of Finance* 17(2): 625-652.

Survival of Overconfidence in Currency Markets, joint with Thomas Oberlechner (2012). *Journal of Financial and Quantitative Analysis* 47(1): 92-113.

Foreign Exchange Market Structure, Players, and Evolution (2012), with Michael King and Dagfinn Rime. In: James, J., Marsh, I., Sarno, L. (Eds), *Handbook of Exchange Rates*. (Wiley and Sons: New York and London).

Price Discovery in Currency Markets, joint with Alexander Mende and Lukas Menkhoff (2011). *Journal of International Money and Finance* 30 (8): 1696-1718.

Extreme Returns: The Case of Currencies, joint with Tanseli Savaser (2011). *Journal of Banking and Finance* **35**: 2868-2880

Limit-Order Submission Strategies under Asymmetric Information. Joint with Lukas Menkhoff and Maik Schmeling (2010). *Journal of Banking and Finance* 34(11): 2665-2677.

Foreign Exchange Microstructure: A Survey (2009). *Encyclopedia of Complexity and System Science,* Robert A. Meyers, Ed (Springer: New York).

The Exchange Rate in a Behavioral Finance Framework (2007). Book Review: *Journal of International Economics* 72: 265-270.

Macro Lessons from Microstructure (2006). *International Journal of Finance and Economic*s 11: 55-80.

Stop-Loss Orders and Price Cascades in Currency Markets (2005). *Journal of International Money and Finance* 24: 219-241.

Currency Orders and Exchange-Rate Dynamics: Explaining the Success of Technical Analysis (2003). *Journal of Finance* 58: 1791-1819.

The Changing Landscape of the Financial Services Industry: What Lies Ahead? (2000). *Economic Policy Review* 6 no. 4: 39-54. www.ny.frb.org/rmaghome/econ_pol/900lown.pdf

Support for Resistance: Technical Analysis and Intraday Exchange Rates (2000). *Economic Policy Review* 6, no. 2: 53-67. http://www.newyorkfed.org/research/epr/00v06n2/0007osle.html

Rapidly Rising Corporate Debt: Are Firms Now Vulnerable to an Economic Slowdown? (2000). *Current Issues in Economics and Finance* 6, no. 7: 1-6.

Rational Speculators and Exchange Rate Volatility with John Carlson (2000). *European Economic Review* 44: 231-253.

Methodical Madness: Technical Analysis and the Irrationality of Exchange-Rate Forecasts, with Kevin Chang (1999). *Economic Journal* 109: 636-661.

Second District House Prices: Why So Weak in the 1990s? joint with Matthew Higgins and Anjeli Sridhar (1999). Federal Reserve Bank of New York *Current Issues in Economics and Finance* 5(January).

Short-Term Speculators and the Puzzling Behavior of Exchange Rates (1998). *Journal of International Economics* 43(1): 37-58.

Is More Always Better? Head-and-Shoulders and Filter Rules in Foreign Exchange Markets, joint with P.W. Kevin Chang (1998). In: E. Acar and S. Satchell, eds., *Advanced Trading Strategies and Tactics.* (Irwin-Probus: London).

Asset Market Hangovers and Economic Growth: U.S. Housing Markets, joint with Matthew Higgins (1998). In: *The Role of Asset Prices in the Formulation of Monetary Policy*, BIS Conference Papers Vol. 5 (Bank for International Settlements, Basle).

Asset Market Hangovers and Economic Growth: The OECD During 1984-1993, join with Matthew Higgins (1997). *Oxford Review of Economic Policy* 13(3): 110-34.

Charting : Chaos Theory in Disguise? joint with William Clyde (1997). *Journal of Futures Markets* 17(August): 489-514.

Exchange Rate Dynamics and Speculators' Horizons (1995). *Journal of International Money and Finance* 14: 695-719.

The Credit Slowdown Abroad, joint with S. Hickok (1994). In: *Studies on Causes and Consequences of the 1989-92 Credit Slowdown* (Federal Reserve Bank of New York): 429-73.

High Real Interest Rates and Investment in the 1990s (1994). Federal Reserve Bank of New York *Quarterly Review* 19(1): 38-44.

Interest Rate Term Premiums and the Failure of Uncovered Interest Rate Parity (1992). *Journal of International Financial Markets, Institutions and Money* 2(2): 1-26.

Factor Prices Under Integrated Markets for Risky Capital, (1991). *European Economic Review* 35: 1311-40.

Explaining the Absence of International Factor-Price Convergence (1991). *Journal of International Money and Finance* 10: 89-107.

Optimal Growth Under Uncertainty (1991). *Economic Letters* 36: 31-35.

OTHER PUBLICATIONS

Greece Illustrates the Importance of Staying Within Economic Limits (2015). *European Politics and Policy* (London School of Economics) September 1. http://blogs.lse.ac.uk/europpblog/2015/09/01/greece-illustrates-the-importance-of-staying-within-economic-limits/

Reading Between the Lines of Greece's Bailout: Debt Relief is Inevitable – Just Not Yet (2015). *The Conversation*. July 20. http://theconversation.com/reading-between-the-lines-of-greeces-bailout-debt-relief-is-inevitable-just-not-yet-44744

The Fix Is In (2014). *The Conversation*. November 13. http://theconversation.com/the-fix-is-in-how-banks-allegedly-rigged-the-us-5-3-trillion-foreign-exchange-market-33828.

WORKING PAPERS

Shrouding and the Forex Trades of Global Custody Banks. (with Tanseli Savaser). https://ideas.repec.org/p/brd/wpaper/118.html. Resubmitted to the *Journal of Banking and Finance.*

Price Discrimination in OTC Markets. (with Geir Bjønnes and Neophytos Kathitziotis). January, 2017.

Dealer Trading at the Fix (with Alasdair Turnbull). September 2020.

Private Non-fundamental Information and Adverse-Selection in Cryptocurrencies, November 2019, joint with Shuran Zhang.

Information Content of Marketable Limit Orders, November 2019, joint with Shuran Zhang.

Short-Run Exchange-Rate Dynamics: Theory and Evidence, with J. A. Carlson and C. Dahl.

WORK IN PROGRESS

Explaining the Intraday Behavior of Spreads in the Foreign Exchange Interbank Market, joint with David Simon and Shuran Zhang

OTHER ACADEMIC ENGAGEMENTS

THESIS ADVISING

Current Ph.D.
Neophitos Kathitziotis (Hamburg Univ.)
Karen Smith

Completed Masters Theses
Olzas Kuramazov
Damir Ćosić

Completed Ph.D., Chair
Shuran Zhang
Ly Tran
Rawley Heimer
David Simon
Rimma Yusim Sherman
Vitaliy Vandrovych
Prasandjeet (Vinay) Nundlall
Tanseli Savaser
Jennifer Chu Bender

Completed Ph.D., Committee
Henok Tewolde
Siri Valseth (Norwegian Schl.Mgmt.)
Kjell Jorgenson (Norwegian Schl.Mgmt.)
Tyler Hull Gotham George
Ritti Bumiputra
Eskandar (Sandro) Tooma
Xia Meng
Ma Gang
Heidi Zhao

TEACHING

Courses taught since 2002

- Human Psychology and Financial Decision Making (Brandeis, undergraduates)
- Behavioral Finance and Economics (Brandeis - master's students)
- Applied International Macroeconomics (Brandeis - master's students)
- Trading and Exchanges (Brandeis - master's students)
- Central Banking (Brandeis - master's students)
- Investments (Brandeis - master's-level)
- International Finance (Brandeis - Ph.D. students)
- Financial Market Microstructure (Norwegian School of Management - Ph.D. students)
- Basic Finance (Massachusetts Correctional Institution, Concord)

Past teaching expertise

- Macroeconomics (Amos Tuck School of Business, Dartmouth)
- Bank Management (Amos Tuck School of Business, Dartmouth)
- International Capital Markets (Amos Tuck School of Business, Dartmouth; Kellogg Graduate School of Management, Northwesterm)
- Monetary Theory (Columbia University, undergraduates)
- International Finance (Columbia University, undergraduates and SIPA)

FELLOWSHIPS AND AWARDS

Brandeis University International Business School Teaching Award, 2018.

Martin and Ahuva Gross Chaired Professorship in Financial Markets and Institutions.

Brandeis Teaching Innovation Grant, 2015

Market Technicians Association, Inc., Recognition Award for the Teaching of Technical Analysis in Academia.

Brandeis University International Business School Teaching Award, 2008.

First Prize, Academic Papers Competition, Investors' Forum, December, 1996, for Rational Speculators and Exchange Rate Volatility (with John Carlson).

Faculty Research Fellow, National Bureau of Economic Research, 1987-1991.

Ford Foundation Scholar, National Bureau of Economic Research, Fall 1988.

REFEREE

Ad hoc referee: *Journal of Economic Literature, NSF, Review of Financial Studies, Journal of Finance, Journal of Financial Markets, Journal of Financial and Quantitative Analysis, Journal of Financial Markets, International Economic Review, Journal of Money, Credit, and Banking, European Economic Review, Economic Bulletin, Journal of International Economics, Journal of Development Economics, Journal of Financial Management, IMF Staff Papers, Science, Review of Economics and Statistics, Journal of International Money and Finance, Journal of Economic Behavior and Organizations, European Journal of Finance, Journal of Empirical Finance, Canadian Journal of Economics, Journal of Financial Services Research, Journal of Economics and Business, Journal of Macroeconomics, Journal of Futures Markets, Quarterly Review of Economics and Finance, Applied Operations Research, Quantitative Finance.*

SEMINARS AND CONFERENCE PRESENTATIONS

Discussant: Locked-in at home: Female Analysts' Attention at Work During the COVID-19 Pandemic. Mengqiao Du. Northern Finance Association Annual Meeteings, September 2021.

Presenter: Workplace Bullying in Economics: Nature, Consequences, and Recommended Policies, Southern Economic Association Annual Meetings, 2020.

Presenter: Dealer Trading at the Fix. December, 2019. 3rd Sydney Banking and Stability Conference, Sydney, Australia. Also: discussant.

Presenter: Dealer Trading at the Fix. October, 2018. FMA Meetings, San Diego, CA. Also: discussant.

Presenter: Dealer Trading at the Fix. June 12, 2018. Infiniti Conference on International Finance, Poznan, Poland. Also: discussant.

Presenter: Dealer Trading at the Fix. December 15, 2017. Second annual Conference on High Frequency Exchange Rate Dynamics: Econophysics and Econometric Analysis Based on the EBS data sets. Tokyo, Japan.

Presenter: Dealer Trading at the Fix. December 21, 2017. Eurofidai Conference, Paris, France.

Discussant, Did the Reform Fix the London Fix problem? By Takatoshi Ito and Masahiro Yamada. March, 2017: International Conference on High Frequency Exchange Rate Dynamics: Econophysics and Econometric Analysis Based on the EBS data sets. Tokyo, Japan

Discussant: Puzzles in the Tokyo Fixing in the Forex Market: Order Imbalances and Bank Pricing? By Takatoshi Ito. March 2017: International Conference on High Frequency Exchange Rate Dynamics: Econophysics and Econometric Analysis Based on the EBS data sets. Tokyo, Japan

Presenter: Dealer Trading at the Fix. December 2016: 6th Workshop on Financial Determinants of Foreign Exchange Rates, Cass Business School, London.

Presenter: Bank Reserve Management After the Global Financial Crisis, IBS Brown Bag, December 2016.

Presenter: Price Discrimination in OTC Markets. November 2016, Wilfried Laurier University, Ontario, Canada.
Presenter: Dealer Trading at the Fix. October 2016: Financial Management Association Annual Meetings, Las Vegas.
Presenter: Dealer Trading at the Fix. October 2016. OECD, Paris.
Presenter: Dealer Trading at the Fix September 2016: 12th Annual Central Bank Workshop on the Microstructure of Financial Markets, Banque de France, Paris.
Presenter: Dealer Trading at the Fix. September 2016: Portsmouth-Fordham Conference on Banking and Finance, University of Portsmouth, UK.
Presenter: Dealer Trading at the Fix. September 2016: Cass Business School, London.
Presenter: Price Discrimination in OTC Markets. September 2016, CFM (Hedge Fund) Paris.
Presenter: Dealer Trading at the Fix. September 2016: University of Essex Business School, Colchester, England.
Discussant: June 2016: Illiquidity in the stock and FX markets: an investigation of their cross-market dynamics by Chiara Banti. Women in Microstructure conference, Park City, UT
Presenter: Price Discrimination in OTC Markets. April 2016: Eastern Finance Association meetings, Baltimore, MD.
Discussant: Libor's Poker. By Jiakai Chen. April 2016: Eastern Finance Association meetings, Baltimore, MD.
Presenter: Depth and Information in the Foreign Exchange Limit Order Book: A Nonlinear Approach (with Ly Tran). June 2015, Women in Microstructure Conference.
Discussant: Forex Trading and the WMR Fix, by Martin D.D. Evans. NYU-Stern Annual Microstructure Meetings, May 2015.
Discussant: Understanding FX Liquidity, Karnaukh, Ranaldo, Soöerlind, 10th Annual Central Bank Workshop on the Microstructure of Financial Markets, Rome, Italy, October 2014.
Presenter: Asymmetric Information and the Foreign Exchange Trades of Global Custody Banks, Joint with Tanseli Savaser and Thang Tan Nguyen. Midwest Finance Association Annual Meeting, New Orleans, February 23, 2012.
Discussant: Mink, Mark, Procyclical Bank Risk-Taking and the Lender of Last Resort, DNB Working Paper No. 301 (July 2011). Midwest Finance Association Annual Meeting, New Orleans, February 23, 2012.
Presenter: Noise Trading and Illusory Correlations in U.S. Equity Markets, joint with Jennifer Bender and David Simon. Behavioral Finance Working Group Conference, Cass Business School, London. (presented, due to time conflict, by David Simon) April 7, 2011.
Discussant: Market Reaction to Second-Hand News: Attention Grabbing or Information Dissemination? Cervellati, Enrico Maria, Riccardo Ferretti, and Pierpaolo Pattitoni (presented by David Simon). April 7, 2011.
Presenter: Extreme Returns: The Case of Currencies, joint with Tanseli Savaser. Boston QWAFAFEW, July 2010.
Presenter: Hedge Funds and the Origins of Private Information in Foreign Exchange Markets, French Finance Association Meetings, Paris, December 16, 2009.
Presenter: Uninformed Momentum Traders, Ali Emre Konokoglu, Discussion, French Finance Association Meetings, Paris, December 16, 2009.
Presenter: Technical Analysis of Equity Indexes, Warwick Business School, University of Warwick, U.K. December 2, 2009.
Presenter: Technical Analysis of Equity Indexes, AFATE, Paris, December 16, 2009.
Presenter: Technical Analysis of Equity Indexes, Society of Technical Analysts, London, November 10, 2009.
Presenter: Overconfidence in Currency Markets, Cass Business School, London, November 4, 2009.

Presenter: Exchange-Rate Effect of Multi-Currency Arbitrage, Harald Hau, Discussion, Sixth Annual Central Bank Workshop on the Microstructure of Financial Markets, Zurich, Switzerland, October 8, 2009.

Presenter: Hedge Funds and the Origins of Private Information in Foreign Exchange Markets, Bank for International Settlements, Basel, October 7, 2009.

Presenter: Extreme Returns Without News: The Case of Currencies, Financial Economics Research Center Conference on Microstructure, September 23, 2009.

Discussant, Crash Risk in Currency Markets, Romain Ranciere, Xavier Gabaix, Adrien Verdelhan, Emmanuel Farhi, Discussant, Western Finance Association Meetings, San Diego, June 17-20, 2009.

Presenter: Hedge Funds and the Origins of Private Information in Foreign Exchange Markets, Third Annual Microstructure Workshop, Emerging Markets Group, Cass Business School, London, May 1, 2009.

Panelist, Causes and Consequences of the Financial Crisis, Jean Beer Center for Ethics, Philosophy Department, Georgia State University, Atlanta, GA, March 18, 2009.

Presenter: Extreme Returns Without News: The Case of Currencies, State Street Advanced Research Center, March 11, 2009.

Presenter: Extreme Returns Without News: The Case of Currencies, International Federation of Technical Analysts, Paris, November 6-8, 2008.

Presenter: Extreme Returns Without News: The Case of Currencies, Midwest Finance Association meetings, Dallas, Texas, October 2008.

Presenter: Short-Run Exchange-Rate Dynamics: Theory and Evidence, Infiniti Conference, Dublin, Ireland, June 2008.

Presenter: Short-Run Exchange-Rate Dynamics: Theory and Evidence, Seminar at UNH Durham, October 2007.

Presenter: Asymmetric Information in the Interbank Foreign Exchange Market, Joint with Geir Bjønnes and Dagfinn Rime, *Third Annual Conference on Market Microstructure*, Budapest, Hungary, September 15, 2007.

Presenter: Extreme Returns: The Case of Currencies, joint with Tanseli Savaser. *Third Annual Conference on Market Microstructure*, Budapest, Hungary, September 15, 2007

Presenter: Price Discovery in Currency Markets, Seminar Presentation at the NBER Conference on Microstructure, May 11, 2007.

Presenter: Price Discovery in Currency Markets, Seminar Presentation at Acadian Asset Management, April 4, 2007.

Presenter: Short-Run Exchange-Rate Dynamics: Theory and Evidence, Seminar at Williams College, April 2, 2007.

Presenter: Price Discovery in Currency Markets, Seminar presentation at Rutgers University, November 28, 2006.

Presenter: Price Discovery in Currency Markets, Seminar at State Street Global Research Advanced Research Center, December 2007.

Presenter: Short-Run Exchange-Rate Dynamics: Theory and Evidence, seminar presentation at Hannover University, Hannover, Germany, November 15, 2006.

Presenter: Price Discovery in Currency Markets, seminar presentation at the University of Copenhagen, Copenhagen, Denmark, November 13, 2006.

Presenter: Price Discovery in Currency Markets, Bank of Canada/Norges Bank Conference on the Microstructure of Equity and Foreign Exchange Markets, Ottawa, Canada. October 20-21, 2006.

Presenter: Price Discovery in Currency Markets, Seminar presentation at the Federal Reserve Bank of St. Louis, October 4, 2005.

Presenter: Price Discovery in Currency Markets, Hong Kong Institute for Monetary Research Conference on financial Markets and the Macroeconomy. Hong Kong, July 13-14, 2006.
Presenter: Price Discovery in Currency Markets, MMF/ESRC/WFRI Workshop on the Micro Structure of FX markets and Fixed Income. Warwick University Business School, Wednesday 28th June 2006.
Presenter: Macro Lessons from Microstructure, Seminar presentation at University of North Carolina, April 1, 2006.
Presenter: Macro Lessons from Microstructure, Seminar presentation at the Bank of Canada, April 12, 2006.
Presenter: Macro Lessons from Microstructure, Seminar presentation at University of Virginia, March 1, 2006.
Presenter: Getting Tenure, CSWEP Annual Mentoring Conference, Boston, MA, January 10, 2006.
Presenter: Short-Run Exchange-Rate Dynamics: Theory and Evidence, American Economic Association Annual Meetings, Boston, MA January 8, 2006.
Presenter: Macro Lessons from Microstructure, Econometric Society Annual Meetings, Boston, MA, January 7, 2006.
Presenter: Short-Run Exchange-Rate Dynamics: Theory and Evidence, Norges Bank Conference on Equity and Foreign Exchange Microstructure, Oslo, Norway: September 7-8, 2005.
Presenter: Asymmetric Information and Currency Spreads, Bank of Canada/University of British Columbia Workshop on International Financial Markets, University of British Columbia: August 23-24, 2005.
Presenter: Asymmetric Information and Currency Spreads, Summer School and Workshop on Market Microstructure, Aix-en-Provence: July 4-8, 2005.
Presenter: Short-Run Exchange-Rate Dynamics: Theory and Evidence, Seminar presentation at the Federal Reserve Bank of Boston: May 2005.
Presenter: Stop-Loss Orders and Price Cascades in Currency Markets, Eighth International Conference on International Macroeconomics and Finance, University of Crete, Greece: May 26-28, 2004.
Presenter: Short-Run Exchange-Rate Dynamics: Theory and Evidence, Seminar at Federal Reserve Bank of Boston May 2004.
Presenter: Extreme Exchange-Rate Returns Without News: A Microstructural Approach, A series of seminars and private presentations to the clients of the Royal Bank of Scotland in London and New York. Fall 2003 and summer 2004.
Presenter: Identifying Noise Traders: The Head-and-Shoulders Pattern in U.S. Equities. 4th Empirical Finance Conference, Financial Markets Group, London School of Economics: April 30, 2003.
Presenter: Stop-Loss Orders and Price Cascades in Currency Markets, Currency Market Microstructure Conference, Stockholm Institute of Finance, Stockholm: April 12, 2003.
Presenter: Identifying Noise Traders: The Head-and-Shoulders Pattern in U.S. Equities. Conference on Computational Finance, New York, NY, January 1999.
Presenter: Identifying Noise Traders: The Head-and-Shoulders Pattern in U.S. Equities. Financial Management Association Annual Meetings, New York City, October 1998.
Presenter: Identifying Noise Traders: The Head-and-Shoulders Pattern in U.S. Equities. Conference on Forecasting Financial Markets sponsored by Imperial College, London, and Banque National de Paris. London, May 27-29, 1998.
Presenter: Identifying Noise Traders: The Head-and-Shoulders Pattern in U.S. Equities. French Finance Association Annual Meetings, Grenoble, France, June 23-25 1997.
Presenter: Head-and-Shoulders: Not Just a Flaky Pattern, System Committee on International Economics Fall Meeting, Kansas City, 1995
Presenter: Head-and-Shoulders: Not Just a Flaky Pattern, Financial Management Association Annual Meetings, New York, New York, October 1995.

Presenter: Head-and-Shoulders: Not Just a Flaky Pattern, Conference on Forecasting Financial Markets, London, April 1995.

Presenter: Head-and-Shoulders: Not Just a Flaky Pattern, Eastern Economic Association Meetings, New York, NY, March 1995.

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